mind over machine

TurboCare®
Loveland Controls Operations

September 27, 2004

**Mr. James H. Nelson**
**Intermountain Power Service Corp.**
**850 W. Brush Wellman Road**
**Delta, Utah 84624 - 9522**

**Subject: Boiler Feed Water pump drives budgetary retrofit solution.**

**Loveland Doc # U4101**

Dear: Mr. Nelson

Thank you very much for the opportunity to allow us to visit your plant and to provide you with the following budgetary proposal for the retrofit of the controls of your GE steam turbine driven Boiler Feed Water Pumps.

Our approach would involve a highly reliable controls and actuating devices retrofit wherein we would eliminate all potentially troublesome and possibly obsolete components and replace them with state of the art digital and high-pressure servo-actuating systems. The net effect should be considerable increased operating reliability, and improved controls dynamics/performance. Our retrofit approach for your units would integrate a mix of simplex, and redundant systems to achieve a smart reliable retrofit of these controls.

We would welcome and value any observations and/or comments that you may have on the following proposal.

Sincerely,

**TurboCare, Inc**

*Luis E. Echegaray*

Luis E. Echegaray
Sales and Marketing Manager

# 1 BFPT UNITS CONTROLS UPGRADE

## 1.1 Introduction

Improvements to the operation and reliability of the GE turbine driven Boiler Feed Water pumps will focus on improvements to the reliability of their governor systems, trip valve actuation systems, overspeed trip system and improvements on the ability to interface the controls to the existing plant DCS system. With this in mind, TurboCare, Inc. proposes a governor system upgrade and hydraulic systems retrofit which would in turn result in performance improvements to the turbine while increasing the turbine reliability and maintainability. With this retrofit TurboCare, Inc. will completely eliminate the existing governor oil system and the Speedtronics™ Mark II analog speed control systems. A digital, field programmable Woodward 505 controller would be integrated to the turbine skid to replace the "obsolete" Mark II, several pressure switches used with the governor oil system, and all the rest of the existing governor oil hydraulics. The Woodward 505 would modulate the existing steam rack valve directly from a new high-pressure hydraulic servo-actuator.

The Woodward 505 has provided over 20,000 users reliable trouble free operation. Due to it's rugged but smart digital architecture and the user-friendly configuration software, the 505 has become the most popular steam turbine control system in the world. The 505 controller is easy to maintain and replace in the unlikely event of a system and component failure. It is the writers opinion that the optimal cost effective, upgrade solution for the Intermountain BFP drivers should focus in providing a balanced reliability system where redundancy is utilized in critical trip and operating components. These critical trip and operating components should be fail safe and on-line testable and replaceable as much as practical. The upgrade of the turbines hydraulic systems, would also gain the user the additional benefit of allowing the 505 to integrate the optimal capabilities of dynamic speed and responsiveness in control, and superior turbine protection. An additional side benefit would be an improvement of the stop/trip valve operational reliability by replacing the actuator with a high pressure, highly reliable actuator, the replacement of the overspeed governor system with the ProTech 203 triple modular redundant overspeed protection system, and TurboCare's exclusive Steam Turbine Redundant Testable Trip Device (RTTD).

From a mechanical standpoint, this configuration will retain the existing control valve rack(s). The new control valve actuator will only replace the current control valve hydraulic actuator and will reside in the same location with new custom bracketing.

## 1.2 Governor Control

The 505 Digital Governor is a microprocessor-based steam turbine controller designed to control single-actuator steam turbines of all sizes. A microprocessor-based digital control provides you with considerable flexibility in configuring the governor to your specific control requirements. This field configurability allows a single part number to be used in many different control applications, and it reduces both cost and delivery time.

The 505 have a full operator interface in the front of the unit. A 48 character front display allows for the local monitoring of all configured critical control parameters. A 30 key membrane keyboard is used to configure the 505, make on-line program adjustments (pass word protected) and operate the turbine/system. The 505 field programmability, will allow the site

engineers to configure the control to their specific application, and make future control configuration, alarm and trip set-point and/or parameters changes. In most cases these changes can be easily and reliably made by the plant engineer on line. Over 100 on-line tunables are available to allow program refinements while a unit is running. Inputs and Outputs are programmable as required by the application or interface.

**Communications.**

The 505 controls can communicate directly with plant Distributed Control Systems (DCS) and/or CRT based operator control panels, through two Modbus® communications ports. These ports support RS-232, RS422, and RS 485 communications using ASCII or RTU Modbus transmission protocols.

Communications between the 505 and the plant DCS can also be performed through hardwired connections. Since all 505 PID setpoint can be controlled through analog input signals, interface resolution and control is not sacrificed.

**Integral protections of the 505 are:**

- Integral Overspeed Protection Logic
- First-out Indication (3 individual Shutdown inputs)
- Bumpless transfer between control modes if a transducer failure is detected
- Local/Remote Control priority and selection
- Fail-safe Shutdown Logic

**Integral Feature of the 505.**

- Critical speed avoidance (2 speed bands).
- Auto start sequence (hot and cold starts).
- Valve Limiters.
- Security (Program is password protected).
- Dual speed/load dynamics.
- First out indication (shutdowns).
- Zero speed detection with proximity probe.
- Peak speed indication for overspeed trip.
- Two programmable function keys on the 505's front panel.
- Hand valve operation.
- Two independent Modbus comm. Links.
- Remote analog setpoint for speed/load, aux., and cascade.
- Program upload/download capability

### 1.3.1 Control Modes

With the 505 Intermountain Power could automatically control the turbine/pump output per boiler level requirements, pump output requirements, cascaded Inlet or exhaust pressure control, from DCS commanded participation control (remote control) or from manual speed raise/lower controls.

#### 1.3.1.1 Remote Process Control Loop

The remote process control can control the speed reference set point. An external process control receives a 4 to 20 mA signal from a transducer (like boiler feed water level). The process controller compares that signal with an external reference to generate a speed change output as to satisfy the remote process signal control demand.

#### 1.3.1.2 Cascade Control Loop

The cascade control can control the speed reference set point. It operates in the same manner as the remote process control. The cascade control contains a deadband comparator. This compares a 4 to 20 mA process signal with an internal reference signal. If the two signals do not match, the comparator issues raise or lower commands to the speed reference until the error is less than the deadband. In the event that the "Cascaded" signal is lost and/or a transducer failure is detected the controller would revert to a preset speed control setpoint. Cascade control loops for this application could be based on steam inlet or exhaust pressure control.

#### 1.3.1.3 Valve Ramp Control

The valve ramp control opens and closes the steam valve to aid in starting and shutting down the turbine. The ramp is adjusted through the keypad on the front of the control. External contact closures also allow remote setting of the ramp.

### 1.3.2 505 Initiated Shutdown and CPU Fault Control

An emergency shutdown circuit and a CPU failed circuit automatically control the output of the 505. If you press the Emergency Stop pushbutton on the front of the control, the shutdown circuitry pulls the control output bus low, which in turn run the actuator output current to minimum. The CPU failed circuit functions as a watchdog timer, which monitors the microprocessor operation. If the microprocessor has not executed a control calculation within a preset sampling period, the watchdog timer also pulls the controller output low, which in turn runs the actuator current to minimum.

## 1.4 Governor Hydraulic Oil

The existing governor oil system utilizes turbine lube oil to actuate and pressurize several primary and secondary devices of the system. The net effects of this are; higher maintenance requirements on the oil due to the contaminants and higher operating temperatures of the oil, which affect its compressibility, and lubricating efficiency.

As part of the retrofit, a "blanking kit" is being provided to cap off and isolate the governor oil ports and hoses no longer required with the new configuration.

The proposed upgrade would result in lower lube oil operating temperatures, higher pressure and less impurities.

<u>The proposed upgrade would eliminate the need for the following devices:</u>

1. Speedtronics II Speed governor & relays.
2. Hydraulic pressure switch's and solenoids panel.
3. Integral main power cylinder and servo including stop valve interlock.
4. Trip valve mechanical controls and overspeed trip bolt.
5. Trip test valve.

6. Mechanical linkages to speed and overspeed governor.
7. Hand hydraulic trip & reset.
8. Trip dump valve.
9. Active speed probes bracket assembly.

The above components would be replaced with the following:

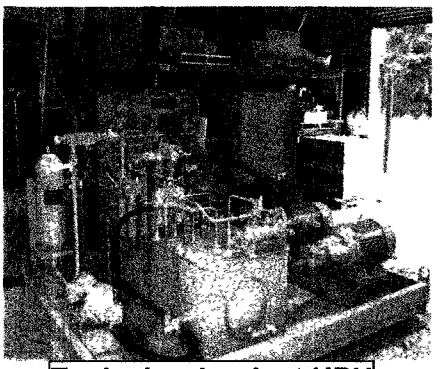
1. Woodward 505 Digital Control for Steam turbines.
2. HP (to 1800 psig) power skid.
3. HP Inlet rack control servo-actuator with dual LVDTs, servo-motor/amplifier and custom bracketing.
4. Woodward's Servo Positioning Controller (SPC).
5. HP trip actuator and bracketing retrofitted to existing trip valve.
6. Redundant testable trip device (RTTD).
7. ProTech 203 Overspeed protection system.
8. 5 ea. Passive probes and one ea. active probe bracket assembly replacement.

## 1.3 **High Pressure Hydraulics system.**

The 505-governor output would act to modulate the steam rack directly from a high-pressure actuator coupled to the existing rack arrangement. The new high-pressure servo-actuator would exhibit much better dynamics than the existing integral low-pressure power cylinder. An integral redundant LVDT assembly (to the servo-actuator) would provide exact position feedback information to the Servo Position Control (SPC), which maintains closed loop control to the 505 commanded positioning signal. The high-pressure hydraulics servo system consists of the high-pressure hydraulic power unit (HPU), servo-actuator assembly for inlet valve rack, servo-positioning controller (SPC), and a high-pressure actuator assembly for stop/trip valve actuated from our redundant testable trip device (RTTD).

### 1.4.1 High Pressure Hydraulic Power Unit (HPU)

A redundant high-pressure power unit will be supplied to power the new inlet steam valve servo-actuator. This unit will feature redundant pressure compensated pumps and motors, check valves, pump isolation valves, suction strainers and filters. The reservoir stainless steel tank and bladder accumulator will be sized to best meet and exceed the application requirements. A NEMA 4 control box assembly will house the electrical connections, motor starters, control switch and pressure gauges. The HPU skid will be designed as to fit the existing medium pressure skid.



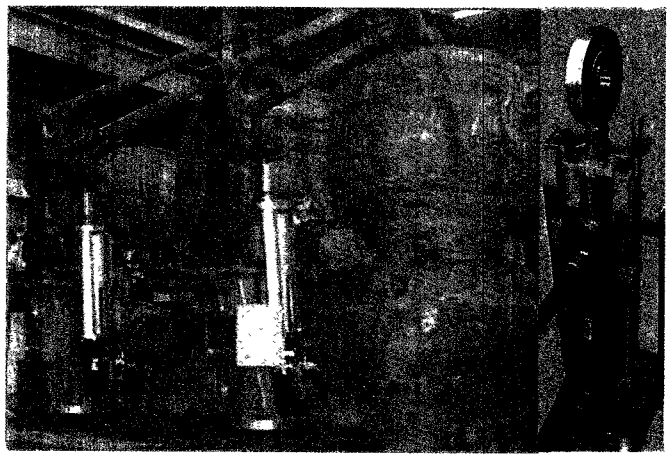
**Typical redundant HPU**

### 1.4.2 High pressure Servo-Actuator

A high-pressure servo-actuator custom solution will be designed to meet and exceed the expected requirements. The bracketing, cylinder size and action will be designed as to provide sufficient force to overcome the steam pressure being exerted in the steam valves plugs plus a significant contingency to overcome any foreseen and unforeseen linkage losses.

As an integral assembly of the servo actuator would be the servomotor, and redundant LVDT (feedback) device. The LVDT will provide specific valve rack position information to the SPC (Servo Positioning Controller). The SPC will compare the position with the position command

from the 505 and issue a open or close command to the actuator via the servomotor. The servomotor ports high-pressure oil to the required side of the high-pressure piston to affect a proportional movement in the desired direction.



HIGH PRESSURE SERVO-ACTUATORS WITH CUSTOM BRACKETING AND REDUNDANT FEEDBACK DEVICES

### 1.4.3 SPC Servo Positioning Controller.

The SPC is an integral electronic actuator positioning system. It receives a position command signal from the 505 and compares it with the actuator position, which it reads from redundant Linear Variable Differential Transformers (LVDTs) attached to the servo-actuator. The SPC generates a "modulated" reference signal, which is an input to the primary of the LVDT and reads and compares the returned (secondary) signal, which gets affected by the LVDT's position (inside the primary field). The calculated position signal is then compared to the position command (from the 505) and an output to either open or close the servo-actuator is commanded via the servomotor.

## 1.5 Trip System

The trip system is designed to provide a redundant, testable, means to electronically trip the turbine. The figure below is the hydraulic schematic for the redundant testable trip device (RTTD). The schematic is shown with the turbine in operation.

### 1.5.1 Trip Panel

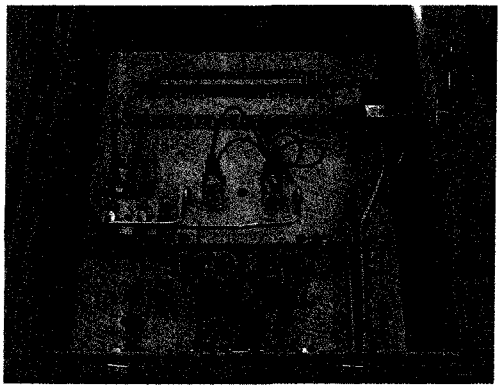
The turbine's stop/trip valve would be maintained but operated from a new high-pressure actuator. TurboCare, Inc "Redundant **Testable** Trip Device" (RTTD) would be integrated to reliably dump and supervise this very critical trip supervisory controller. With the improvements in the lubricating hydraulic medium performance from the removal of the governor oil controls and the addition of the RTTD, turbine trips would be significantly more reliable than with the previous system. Each trip block consists of redundant (two) solenoid valves and pressure switches. When both solenoids are de-energized the supply oil will port directly to drain, and the trip pressure header will drop out and trip the turbine. This panel allows for the on-line stroking and testing of each of the individual trip solenoids for the lube oil, vacuum, and active and inactive thrust position monitors.

#### 1.5.1.1 RTTD Manual Trip Handle and Position Switch

The RTTD will be equipped with a manual trip handle and position switch, which is input to the control system. An additional Pressure transmitter will be provided that resides on the "Trip

Header" for monitoring purposes. This transmitter comes with a 4-20 mA signal connection for connection to end user-supplied device for status indication.

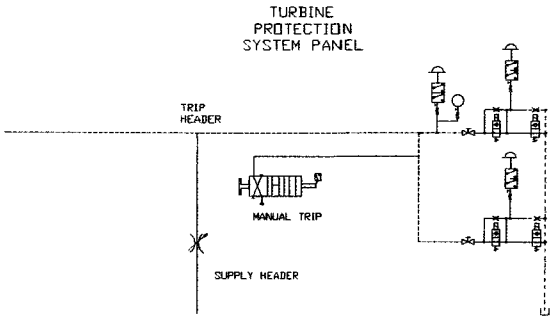
- Replaces antiquated trip block.
- Integrates redundant Lube Oil monitoring.
- Integrates redundant vacuum monitoring.
- Integrates active thrust monitoring.
- Integrates inactive thrust monitoring.
- Integrates redundant outputs trip.
- Trip devices are redundant and "Testable".



Typical Redundant testable trip device.

#### 1.5.1.2 Trip System Testing

The dual solenoids in each trip block allow on-line testing to ensure that each solenoid is functional. Testing is accomplished by monitoring the contacts of the pressure switches when a solenoid is de-energized. To test solenoid #1, the coil is de-energized, then the contacts on pressure switch #1 should change state. A light will indicate that the test was successful. The solenoid is then energized and the contacts on pressure switch #1 should return to its normal state of operation. This completes the test for solenoid #1, and now the process can be repeated for solenoid #2. If the light does not indicate a successful test for 60 seconds, the test is considered failed, and the solenoids may be replaced on line. Testing is recommended to be performed weekly for added reliability.




## 1.6 ProTech® 203 Overspeed Protection System.

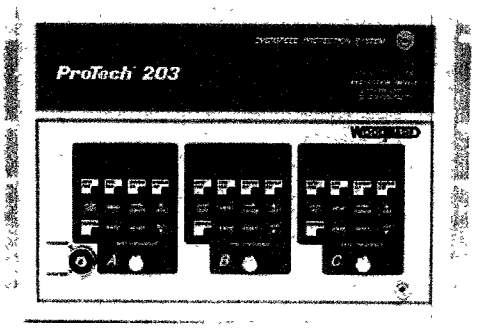
Since we are removing the overspeed bolt, a ProTech 203 redundant overspeed protection system will be included with our base offering.

For overspeed protection, the first line of defense is the speed correction of the electronic control system. Secondary overspeed protection will be provided by a Woodward ProTech®203 Overspeed Protection System. Along with the proposed trip system, the ProTech® 203 can replace the existing mechanical overspeed protection. The ProTech®203 is an independent 2-of-3 electronic trip system, and monitors three dedicated magnetic pickups (included with this offer). All three modules should be powered by a separate power feed. Each of the three voting sections and their respective power supplies can be tested and replaced on-line. Sample time is 5 ms; with maximum total response time of 40 ms. Maximum speed is captured and displayed in the case of an overspeed event. The overspeed protection system is set up to test each speed channel on a periodic basis for proper operation and ability to determine a trip condition.

Because of the periodic testing of the overspeed protection, there is no need to actually overspeed the unit.

With the ProTech 203 TurboCare would provide an additional 3 new passive speed probes dedicated to the Overspeed Protection System. Speed can be measured accurately down to approximately 100 rpm. The passive speed probes included here are the same types used by the control system for speed control, therefore a spare probe can be used for either purpose.

## ProTech 203




- **Two out of three voting.**
- **Independent power supply for each channel.**
- **Unmatched accuracy and repeatability.**
- **Each unit can be independently tested & replaced on-line.**
- **Stores and display highest speed.**

### 1.7 Drawings and Documentation

Standard documentation is a part of this quotation, and includes:

- Valve Positioners Layout and Construction Diagrams
- RTTD assembly Layout and Construction Diagram
- All manuals and cut sheets of equipment devices taken as options
- Bill of Materials

One Custom Manual in "rough usage" binders, which will contain all the above drawings, as well as Standard hardware manuals and cut sheets for all products provided. One copy of the manual is also provided on CD.

### 1.8 Factory Acceptance Test (FAT)

A two-day customer-witnessed factory acceptance test is included with this offering. The FAT involves witnessing all deliverables of the control system and running closed loop simulation (test stand) on one of the 4 systems. All control system functionality will be demonstrated per the Factory Acceptance Test Plan, and additional (reasonable) requested testing will be accommodated.

### 1.9 Engineering scope

- Design Engineering
  - System review
  - Engineer modifications to existing design
  - Design of new High-pressure hydraulic servo-actuator assembly and brackets.
  - Design of retrofitted trip valve hydraulic system and overspeed components.
  - Review interface requirements to electronic devices
  - Project management
- Drawings and Instructions
  - Provide hydraulic schematic of RTTD mechanism
  - Provide complete schematic of High Pressure HPU
  - Complete installation instruction drawings for scope of supply

## 1.10 Pricing, Controller and systems.

| BASE OFFER DESCRIPTION & PRICING | Qty | Cost |
|---|---|---|
| Woodward 505 field configurable controller.<br>❑ 16 ea. Contact inputs, 8 relay outputs.<br>❑ 6 ea. Programmable analog inputs, 8 outputs.<br>❑ 2 ea. Serial Modbus comm. ports.<br>❑ 2 ea. Magnetic speed probes inputs.<br>❑ Local operator control panel with a 2 line, 24 characters each, display and 30 key, operator and field programming keyboard.<br>❑ Panel mount kit for local mounting. | 1 | |
| High Pressure Redundant HPU<br>❑ Stainless Steel reservoir tank.<br>❑ Redundant pump, motors filters and pressure switches.<br>❑ Local full control panel.<br>❑ Spare Filters (kidney, high press) | 1 | |
| High Pressure Servo-Actuator assembly.<br>❑ Design to integrate redundant LVDTs.<br>❑ Integrate servomotor.<br>❑ Custom bracketing and mount. | 1 | |
| High Pressure Stop/Trip valve actuator assembly<br>❑ Custom bracketing and mount. | 1 | |
| Servo Positioning Controller (SPC).<br>❑ Integral redundant LVDT modulator/demodulator.<br>❑ NEMA 4 enclosure. | 1 | |
| RTTD (Redundant Turbine Trip Device) Mechanical Only<br>❑ Redundant solenoid design w/ single pressure transmitter<br>❑ Plate / panel assembly sized to fit existing cabinetry<br>❑ Integral redundant lube oil pressure, vacuum pressure, active and inactive thrust bearing monitoring. | 1 | |
| LVDT Redundant Kit<br>❑ Each kit contains two (2) LVDTs with mounting hardware. No signal conditioner.<br>❑ Proposal Requirements, (1) control Valve, | 1 | |
| ProTech 203 Overspeed Protection Assembly<br>❑ 3 ea magnetic pick-ups and wiring. | 1 | |
| New Speed pick-up custom assembly. | 1 | |
| Site Engineering Visit<br>❑ Site visit for front standard. Turbine must be tripped. Includes travel expenses for one (2) persons, 2 days at site. | 1 | |
| **Total Base Price (Configuration 1)** | 1 | **$234,213** |

## Turn-key installation

| CONCEPT | Qty | Cost |
|---|---|---|
| **Electrical and Mechanical Labor for Turnkey Installation.** | | |
| ❑ Mechanical labor for 2 men, for 2 weeks to dismantle and isolate governor oil system from lube oil, mount and install HPU and actuators. Plus 1 additional man week for start-up support. Total of 5 mechanical labor man weeks @ $3,250.00/ 50 hour man week. | 5 | $16,250 |
| ❑ Travel expenses @ $700 per trip. | 2 | $1,400 |
| ❑ Per Diem for Mechanical labor @ $100.00/day/man. | 35 | $3,500 |
| ❑ Electrical labor for 2 electricians for 3 man weeks each, for interconnecting and loop tests of 505, HPU, actuators, solenoids, magnetic pick-ups, and new ProTech 203. Total of 6 man weeks of electrical labor @ $3,250.00/ 50 hour man week. | 6 | $19,500 |
| ❑ Per Diem for Electricians @ $100.00/day/man. | 42 | $4,200 |
| ❑ Travel expenses @ $700 per trip. | 2 | $1,400 |
| **Application/Project engineer** | | |
| ❑ Application/Project engineers for 3 man weeks @ $7,920 per 48 hour man week. | 3 | $23,760 |
| ❑ Travel expenses @ $700 per trip. | 1 | $700 |
| ❑ Per diem for Applications/Project engineer @ $65/day | 21 | $1,365 |
| **Installation Materials, electrical and mechanical, lot.** | 1 | $5,000 |
| **Total Installation and commissioning** | | $77,075.00 |
| **Total Turn Key project / Unit = $234,213 for systems + above =** | | $311,288.00 |

**Total Project considering all 4 units and a 10% deduct on materials/systems for units 2-4.**

| Description | Qty | Cost |
|---|---|---|
| ❑ Complete scope systems first unit. | 1 | $234,213 |
| ❑ Complete scope systems units 2 – 4 (10% discount). | 3 | $632,375 |
| ❑ Services and commissioning | 4 | $308,300 |
| ❑ One time factory acceptance test | 1 | $13,000 |
| ❑ One lot spares per list below | 1 | $46,710 |
| **Total Project** | | $1,234,598.00 |

## 1.4 Recommend Spare Parts:

(Price valid only when spares purchased with system)

| Recommended Spares | Quantity | Sell Price |
|---|---|---|
| Pressure switch | 1 | $ 455 |
| Passive MPU, explosion and oil proof | 1 | $ 410 |
| Solenoid Assembly | 1 | $395 |
| Solenoid Cable | 1 | $75 |
| LVDT | 1 | $1,200 |
| LVDT Signal Conditioner - Woodward 8272-824 | 1 | $900 |
| SPC Servo Positioning controller | 1 | $2,925 |
| 505 Field configurable governor system & controller | 1 | $8,600 |
| RTTD Redundant testable trip device | 1 | $10,160 |
| High Pressure servo-actuator | 1 | $10,080 |
| High pressure trip valve actuator | 1 | $6,720 |
| HPU pump and motor assembly | 1 | $4,790 |
| **Total recommended spares** | | **$46,710.00** |

## 2 General Contract Terms

TurboCare offers to perform the services detailed in this proposal at the prices and exclusively on the terms and conditions set forth in this offer, unless otherwise noted.

### 2.1 Installation and Startup Services

We could provide additional installation assistance and startup assistance at per Diem rates per attached Price List 1720F, if unexpected additional time is required. For additional time not included in the base scope, the service billing structure is fully explained on Price List 1720F.

As with any project, we will need to work closely with the owner to insure project success. It is typical that the owner will assign a full-time point of contact within their organization for the duration of the project.

Please Note - The site support personnel are the same people that work the project. We will not support site work with personnel from our Field Service organization that has never seen the control system.

### 2.2 Validity:

This is a *firm proposal* and valid for *60* days from the date of this proposal unless otherwise extended, modified, or withdrawn in writing by TurboCare and limits acceptance to the terms set forth herein.

### 2.3 Payment Schedule

The following payment schedule is proposed:

| | |
|---|---|
| 20 % | Upon contract award |
| 35 % | Upon hardware staging in Loveland facility |
| 40 % | Equipment shipment to site |
| 5 % | Commercial operation |

### 2.4 Shipping

All quoted hardware and services in this proposal is FOB, Loveland, Colorado, USA.

This offer is valid for 60 days from the date of this letter unless otherwise extended, modified, or withdrawn, in writing by TurboCare and limits acceptance to the terms set forth herein.

Sincerely,

**TurboCare, Inc**

*Luis E. Echegaray*

Luis E. Echegaray
Sales and Marketing Manager